94-144

90-314

PRESENTATION TO
FEDERAL COMMUNICATIONS COMMISSION
PERSONAL COMMUNICATIONS TASK FORCE

PANEL ON PCS SPECTRUM AND TECHNICAL ISSUES
APRIL 12, 1994

Alex D. Felker
Vice President, Technology
Time Warner Telecommunications

I. INTRODUCTION

Time Warner Telecommunications is a division of Time Warner Entertainment L.P. It was established in 1991 to, among other things, pursue various wireless telecommunications ventures.[1]

Time Warner Telecommunications has been a significant participant in the FCC's development of Personal Communications Services. Besides being an active commenter in the various regulatory proceedings, the company has engaged in a continuing program of experimentation and research into PCS technology and applications, with particular attention to means by which wireless and cable networks can be shared efficiently and economically.

---

[1] Time Warner is the world's leading media and entertainment company, with interests in magazine and book publishing, recorded music and music publishing, filmed entertainment, cable television and cable television programming. The company is upgrading its cable systems into "Full Service Networks" which will provide various state of the art multimedia and telecommunications services. Personal communications services ("PCS") are among the services Time Warner intends to offer.

Time Warner foresees PCS as a fully integrated communications platform that will spawn a wide range of new wireless mobile and fixed telecommunications offerings, affordable to average Americans, while bringing needed competition to cellular and wireline operators. While PCS operators initially will focus on voice applications, Time Warner anticipates that, within a relatively short time period, the "digital-friendly" nature of the new PCS networks will lead to the introduction of an array of un-tethered data and imaging applications which consumers and businesses will soon find indispensable.

New PCS operators will find themselves in a very competitive environment, however. In addition to the rivalry they will face from other new entrants, PCS operators will also be matched against two incumbent cellular operators and, in many areas, at least one existing digital SMR operator. To be successful, the new operators must operate and price efficiently and develop new services and applications: traits which will benefit consumers.

Efficiency and creativity will be useless, though, without a regulatory regime which encourages strong new entry, facilitates early deployment and promotes the development of network infrastructure which minimizes consumer prices and maximizes quality. As discussed below, four crucial elements of such a regime are: 1) wide bandwidth assignments, 2) broad geographic license areas, 3) making cellular licensees ineligible for PCS

licenses within their service areas, and 4) expeditious licensing.

II. PCS ASSIGNMENTS SHOULD BE AT LEAST 40 MHZ/LICENSEE

Time Warner firmly believes that an essential ingredient of an effective PCS regulatory structure is the assignment of ample spectrum to licensees. As discussed below, a 40 MHz assignment plan is optimal. It would both facilitate prompt initiation of service through spectrum sharing with existing microwave users and place the coverage, capacity and cost of PCS systems on par with competing cellular operations. In addition, by increasing trunking efficiency and lowering the number of cell sites needed to meet capacity demands, 40 MHz PCS assignments promote lower infrastructure costs than narrower allotments. Finally, over the longer term, wider bandwidth assignments will simplify the introduction of higher speed, non-voice services and applications.

A. THE RELATIONSHIP BETWEEN PCS BANDWIDTH AND SPECTRUM SHARING WITH INCUMBENT MICROWAVE SYSTEMS

Regardless of the bandwidth assigned to them, PCS licensees will be faced with dealing with the roughly 20,000 private fixed microwave links which now populate the portions of the "emerging technologies band" that are tentatively allocated to PCS (1850-1970, 2130-2150, 2180-2200 MHz). The FCC has adopted a plan under which these links can be relocated involuntarily to other

bands or media three years after PCS licensing.[2] In the case of links licensed to certain public safety entities, this "grandfather period" extends five years beyond licensing.[3] But regardless of whether microwave relocations are voluntary or involuntary, the engineering of new links, the purchase of equipment (which, in light of the fact that less than 500 6 GHz links were constructed last year, probably has yet to be manufactured), the private coordination process, the FCC application and licensing operations, and finally system construction and installation will take years to complete.

1. Rapid PCS Deployment Will Require Sharing

As discussed below, PCS licensees' success will be influenced greatly by how quickly they initiate service. Indeed, operators who commence operations too late may find no market left to penetrate. Thus, PCS operators cannot afford the luxury of waiting until microwave relocation is completed in order to launch service. Consequently, if PCS operators are to begin operation reasonably soon, they will have to "share" the spectrum with incumbent microwave facilities, at least for the foreseeable future. As numerous studies have demonstrated, in the lower PCS sub-band, sharing is not practical under a 20 MHz assignment plan

---

[2] See, Third Report and Order and Memorandum Opinion and order, ET Docket No. 92-9, 8 FCC Rcd 6589 (para. 15-16).

[3] See, Memorandum Opinion and Order, ET Docket No. 92-9, __ FCC Rcd ____ (para. 34-35), (released March 31, 1994).

in many markets. In contrast, with 40 MHz assignments, sharing can occur initially with minimal microwave relocation.[4]

In considering the potential for PCS/microwave sharing, it must be understood that the need to protect these existing operations from interference can limit significantly both the amount of spectrum usable for PCS and the areas in which wireless service can be offered. Moreover, the size of the bandwidth assigned to individual operators, relative to the bandwidth assigned to microwave systems, will affect substantially the degree to which this sharing can be accomplished in a fashion consistent with the creation of a successful business.

Market research studies have found that coverage is among the most important element of consumers' decisions to subscribe to PCS.[5] Therefore, fundamental to the creation of their businesses, PCS operators must provide ubiquitous service within their coverage areas. Consequently, even to initiate service, pieces of spectrum on which PCS operation will not generate interference, must be identified in essentially all areas of a market. If there are regions in which no "clear" spectrum exists, these must be opened up by re-assigning one or more

---

[4] See, e.g., "Spectrum Allocations and Their Impact on Microwave User Relocations: A Case Study," Stephen M. Aspell, Comsearch, April 1993; American Personal Communications, Report on Spectrum Availability for Personal Communications Services Sharing the 1850-1990 MHz Band with the Private Operational Microwave Service (Gen. Docket 90-314 & ET Docket 92-9, November 1992).

[5] See PCS Trial Results: A Telocator Survey 1 (1993).

microwave systems to another frequency band (or other medium) before any service can be initiated. However, proposed microwave protection criteria would require reasonably powered new personal communications systems to coordinate with all existing microwave receivers within **290 kilometers**.[6] Significantly, therefore, a single existing microwave system can preclude PCS operation on a block of spectrum throughout an entire market.

2. Sharing Cannot be Accomplished with 20 MHz Assignments

Even though the 1850-1990 MHz private microwave channels generally are spaced 10 MHz apart, the receivers employed in these links have larger bandwidths. This means that energy on frequencies adjacent to the operating channel can create interference. Consequently, it is common practice for new microwave systems to avoid operation on channels adjacent to existing systems already operating in the local area.

Licensees of PCS systems with 40 MHz assignments can take at least limited advantage of this condition by designing their system around existing microwave facilities. PCS systems with 20 MHz assignments would not be provided the same flexibility, however. Indeed, the existence of a single 10 MHz microwave co-

---

[6] See, Draft Telecommunications System Bulletin TSB-10-F, "Interference Criteria for Microwave Systems," Telecommunications Industry Association, March 25, 1994. The figure cited above (290 km) is presented in Table F-3.2 and is based on a PCS effective isotropic radiated power of 100 watts and an antenna height above average terrain of 90 meters.

channel operation in the service area of a 20 MHz PCS assignment would prevent initiation of any service.

At first glance, it might appear that a 30 MHz PCS assignment plan could provide nearly as much sharing flexibility. Because of the wider-than-10 MHz microwave receiver bandwidths, however, the amount of usable traffic-handling capacity available on unassigned adjacent channels may be small or non-existent under a 30 MHz plan.[7] Moreover, because a single microwave channel could straddle two 20 MHz PCS assignments, relocation negotiations frequently would involve three parties, two of which were competitors. Because a potential information requirement of such negotiations would be technical data from which business plan inferences could be drawn, microwave relocation might be even more drawn out than would otherwise be the case. Ultimately, consumers would suffer from lack of service.[8]

---

[7] This outcome could obtain because the small amount of adjacent channel spectrum usable for PCS would have to be divided and coordinated between operators. Because of lower trunking efficiencies, the few resulting traffic channels could support significantly less subscriber volume than under a 40 MHz assignment plan.

[8] Because the bandwidth parameters are different, the sharing characteristics of the higher sub-band are different than those of the lower band. Regardless of the differences, however, the significant wide frequency spacing between the sub-bands presents the very strong possibility that either equipment compatibility will not exist between PCS operations in the two bands or that subscriber terminals offering compatibility will be uneconomic. In light of these possibilities and the anticipated time and cost constraints PCS operators will face vis-a-vis incumbent competitors, Time Warner urges the Commission to give serious consideration to consolidating all licensed PCS allocations into a common sub-band. Such an approach will expedite service deployment and promote interoperability among

In sum, 40 MHz assignments provide the flexibility that will be required for PCS to commence early operations while sharing with incumbent microwave operations.

B. TO ESTABLISH COVERAGE AND CAPACITY PARITY, PCS REQUIRES GREATER BANDWIDTH THAN CELLULAR

A key determinant of the prices charged for wireless telecommunications will be the capital cost of the underlying infrastructure. New PCS operators' infrastructure costs must be on par with those of competing cellular systems (for comparable levels of coverage and capacity) to be a source of affordable wireless communications and compete effectively with incumbent networks. To achieve such comparability, however, the very significant differences in the physical properties of the cellular and PCS frequency bands must be mitigated. These differences can be offset by assigning PCS operators 40 MHz -- a technically comparable amount of spectrum to that each cellular carrier already has in the 800 MHz band.

1. Physical Relationship Between Coverage and Capacity

As a theoretical matter, the maximum capacity of a communications channel[9] is a function both of the channel's bandwidth and of the ratio, at the receiving end, of desired signal power to undesired interference and noise power. The

---

systems nationwide.

[9] I.e., the data rate at which the incidence of errors can be made arbitrarily small.

basic concept has two parts: the larger the "pipe" the easier it is to push information through, and the stronger the signal the higher the quality of reception. The underlying mathematical relationship illustrates that capacity and coverage (i.e., signal-to-noise ratio) are inversely related and that, within certain ranges, bandwidth and coverage can be substituted for one another without sacrificing channel capacity.[10]

2. Differences Between Cellular and PCS Spectrum

As a general matter, signals at higher frequencies propagate more poorly than those at lower frequencies. All other things being equal, this property of radio propagation acts to reduce the coverage and/or the capacity of 2 GHz systems relative to those operating at 800 MHz. Consequently, with comparable transmitted powers, channel bandwidths and information signals, the coverage area of a 2 GHz PCS station can be expected to be between 1/2 and 1/4 that of an 800 MHz cellular station.[11]

---

[10] Maximum capacity, C (in bits per second), of channel impaired only by "white" noise is defined as,

$$C = W*\log_2(1 + S/N)$$

where,

W = bandwidth in Hz
S = desired signal power
N = undesired noise power

[11] Numerous field tests confirm that transmission attenuation at 2 GHz is much greater than at 800 MHz. See, for example, results of extensive propagation field studies which Time Warner Telecommunications has conducted as summarized in Further Supplement to Request for Pioneer's Preference and Sixth Quarterly Report, September 30, 1992.

3. PCS/Cellular Parity and How to Achieve It

One can define "parity" between cellular and PCS in economic terms. Under this definition, systems in the two bands are on par if, with infrastructures of roughly comparable cost, each can deliver essentially equivalent service over similar geographic regions. Because of the poorer propagation properties at the higher frequencies, however, with equivalent assignment bandwidths, perhaps four times as many 2 GHz base stations are needed to deliver service comparable to 800 MHz cellular. Under these conditions, parity clearly would not exist between PCS and cellular systems.

As is evident from the definition of channel capacity, this disadvantage theoretically can be mitigated partially by employing wider PCS channel bandwidths to deliver the same quantity of information as cellular. Alternatively, smaller quantities of PCS traffic can be delivered over channel bandwidths comparable to cellular.[12] Although in analog systems the tradeoffs may be somewhat difficult to accomplish, in

---

[12] See Guy Jouannelle and Arun Jalan, Compensating for the Differences Between 800 MHz and 1800 MHz Wireless Telecommunications Systems: A Preliminary Analysis, LCC Incorporated (September 1993). This report quantifies many of the factors which contribute to the differences between the frequencies allocated to cellular and PCS and examines various means of compensating for them. The report concludes that increasing the bandwidth assigned PCS operators, relative to the 25 MHz assigned to each cellular licensee, is an effective means of putting 1800 MHz and 800 MHz systems on a more equal footing. The report further concludes that PCS assignments of 50 MHz would go a long way toward establishing equivalence with cellular in terms of coverage, capacity and infrastructure costs.

digital systems some substitution between bandwidth, capacity and coverage is both possible and practical.

For example, the QUALCOMM CDMA digital system being developed for PCS and cellular permits coverage and capacity to be traded off against each other more-or-less continuously.[13] Paper analyses and field tests of the QUALCOMM system suggest that the substantial coverage difference between 2 GHz and 800 MHz can be reduced substantially by operating at traffic loading levels half or less of maximum capacity.[14] Under these conditions, to achieve the same quantity of traffic capacity (at the edge of cell's coverage) as a fully loaded cellular QUALCOMM system, a PCS operation would require at least 100% more bandwidth (i.e., a "clear" 50 MHz).

In sum, in communications systems there exists a fundamental tradeoff between coverage, bandwidth and channel capacity. Using new digital radio technologies, within certain ranges these tradeoffs can be exploited to partially compensate for the differences in physical properties between 800 MHz cellular and 2 GHz PCS systems. Based on paper analyses and field tests of the QUALCOMM CDMA system, it would appear that a PCS system bandwidth

---

13 The Qualcomm system is a spread spectrum scheme which employs code division multiple access (CDMA) and in which as many as 60 telephone conversations share the same 1.25 MHz radio channel.

14 See The CDMA Network Engineering Handbook, vol. I, Qualcomm, Inc., November 23, 1992.

on the order of a "clear" 40 MHz is on par with the 25 MHz already assigned to cellular systems.

C. WIDER BANDWIDTHS ARE ECONOMICALLY EFFICIENT AND SIMPLIFY INTRODUCTION OF ADVANCED NON-VOICE APPLICATIONS

Wider PCS assignment bandwidths offer at least two other longer term advantages in addition to facilitating co-existence between PCS and microwave system and putting PCS systems more on par with their cellular competitors.[15] First, because wider assignment bandwidths would allow operators to increase the number of voice channels provided through a given cell site, average trunking efficiencies would be higher. Thus, in a more mature system, the number of cell sites required to meet a given level of demand would be smaller than otherwise, thereby resulting in lower infrastructure costs. All other things being equal, these efficiencies would lead to lower subscriber prices.

A second longer term advantage of wider PCS assignments, comparable to what 25 MHz assignments render cellular operators, is that they would tend to simplify and make less expensive the provision of advanced, higher data rate digital services (e.g., data and image applications), Although initially PCS operators probably will focus on voice telephony service offerings, Time Warner anticipates that, within a relatively short time period,

---

[15] Significantly, because 40 MHz assignments are needed to make PCS technically comparable to cellular, these wider bandwidths would not put PCS at a competitive advantage to cellular in either of these areas.

the "digital-friendly" nature of the new PCS networks will lead to the introduction of an array of un-tethered data and imaging applications which consumers and businesses will soon find indispensable. Indeed, because non-voice applications may represent significant value-added to its wireless services and help the company distinguish itself from its competitors, Time Warner already is examining various potential proprietary data services.

D. 40 MHZ SHOULD BE ASSIGNED DIRECTLY

As is evident from the preceding sections, 40 MHz assignments are essential to the successful launch and operation of a large scale, effectively competitive PCS which offers a wide array of telecommunications products. While the PCS policies adopted by the FCC in September 1993 establish 10, 20 and 30 MHz assignments, they do not provide for the direct assignment of 40 MHz. Rather, these larger bandwidth assignments would be permitted through the aggregation of an appropriate combination of 30, 20 and 10 MHz frequency blocks.

Narrower assignments produce a larger number of licenses for the agency to issue, and thereby provide at least the appearance of a policy of fostering ownership diversity. As discussed below, however, relying on aggregation, either during or subsequent to the auction, would slow and make more expensive the initiation of service.

1. Spectrum Aggregation is Inefficient

An assumption apparently underlying the aggregation concept is that it essentially is equivalent to licensing 40 MHz spectrum blocs. This is an erroneous assumption. Indeed, as compared to licensing 40 MHz directly, an aggregation scheme could, at worst, result in an inefficient resource allocation. Even under a best case scenario, an aggregation policy would impose substantial transaction costs, delay the initiation of service and lower the proceeds of a public auction.

It has been suggested that, because PCS licenses will be auctioned, an aggregation scheme allows the question of which is a more efficient bandwidth to be settled on auction day. The theory is that, if 40 MHz is a more efficient arrangement, bids for a combination of assignments would be greater than those individual assignments. Unfortunately, such a theoretical result could only obtain under conditions of perfect information and in the absence of inefficiencies due to factors not internalized into the bidding process.[16] As a practical matter, one must expect that the auction results will be suboptimal in the main, and thus will require rationalization through post-auction trading. The scale and scope of these aftermarket transactions will be directly related to how closely the auctioned parcels are matched to marketplace requirements.

---

16 See, Howard Raiffa, James Sebenius and David Lax, "Comparing Auctions of 20 MHz and 40 MHz PCS Assignments," March 1994.

The fact that assembling spectrum blocs in many markets across the country will impose substantial costs is irrefutable. The magnitude of this cost cannot be estimated accurately, but it is surely no less than the $1 billion the FCC itself estimated as the cost of aggregating cellular assignments.[17] At a minimum, it is expected that the auction proceeds would be reduced by at least the amount of any transaction costs.

Equally important is the delay in the start of service created by a policy requiring spectrum aggregation. Again, the cellular experience suggests that years can be consumed in the process of assembling licenses. In contrast to cellular where most operations began before system consolidations occurred, however, it must be expected that no PCS service will commence until a sizeable number of 40 MHz assignments have been created. This conclusion is based on the fact that, in many markets, 40 MHz is essential to coordinating PCS systems around existing microwave operations. Given the expected scale economies national operators hope to capture, it is reasonable to assume that operators will assemble a critical mass of markets with 40 MHz assignments before they devote resources to constructing and operating PCS systems.

In sum, the transaction costs and delay in the activation of service resulting from the license consolidation required by an

---

17 See, Notice of Proposed Rule Making and Tentative Decision, GEN Docket No. 90-314, 7 FCC Rcd 5676, 5699 (para. 56) (1992).

aggregation policy would depress substantially the revenues collected from an auction of 40 MHz assignments. In addition to being discounted to reflect the costs of aggregation, bids would also be reduced to account for the significantly increased business risks associated with assembling the needed licenses.

III. ASSIGNMENT AREAS SHOULD ENCOMPASS VERY LARGE TERRITORIES

As is evident from the trends to consolidate the cellular and SMR industries, wireless markets encompass large geographic areas. This fact should be recognized by the FCC in the assignment of PCS licenses. Time Warner, along with many others, believes that license areas should encompass at least MTA-size regions.

Large license areas would offer two important benefits. First, they would allow PCS licensees to capture infrastructure economies resulting from the use of switching networks that are better matched to regional requirements. Likewise, sales and marketing efficiencies could follow from the creation of regional distribution channels and more effective use of mass media advertising than may be possible in smaller scale systems.

Licensing PCS on a regional-or-larger basis would also tend to simplify settlement of many of the important inter-operator issues which must be resolved for PCS to realize its promise as an economic, ubiquitous personal telecommunications service. Among these are the development of radio and network interface standards and the establishment of signaling networks and data

bases. Because such a scheme would both reduce the complexity of the negotiations on these issues (by reducing the number of parties to them) and increase the value of resolution to each participant, larger area assignments would promote early closure thereby advancing users' interests significantly.

IV. CELCOS SHOULD BE INELIGIBLE FOR PCS WITHIN SERVICE AREA

To ensure that consumers enjoy the low prices and innovation associated with competition, parties with significant cellular interests should not be permitted to hold PCS licenses in the same area. It has been estimated that, without meaningful new competition, cellular's market power will cost the average cellular subscriber more than $5,900 over time.[18] Among other things, PCS is envisioned to provide this much needed competition to the cellular duopoly structure. Moreover, with the technical flexibility already granted to them by the FCC, cellular operators have begun introducing digital technology and are beginning to provide some of the new services PCS licensees are expected to offer, all within their existing 25 MHz assignments. In establishing a new Personal Communications Service, the Commission holds a golden opportunity to break the stranglehold the cellular industry has over the mobile phone user and make wireless services more affordable and accessible to the average

---

[18] See, Thomas W. Hazlett, Market Power in the Cellular Telephone Duopoly, August 1993.

American. The FCC should not squander the opportunity to inject real competition into this marketplace.

V. PCS LICENSING MUST COMMENCE EXPEDITIOUSLY

Based on economic projections Time Warner and many others have conducted,[19] time-to-market is a key indicator of success for PCS licensees. Because a PCS operator must realize a significant level of penetration to achieve profitability, and inasmuch as cellular penetration is growing at a phenomenal rate, operators who initiate service too late may find no market left to penetrate. Thus, even with wide bandwidth, large area assignments, if PCS operators are unable to enter the market soon, they may find it virtually impossible to build a successful business.

Moreover, based on internal Time Warner estimates, every year that PCS licensing is delayed reduces auction proceeds by at least $1 Billion. Consequently, the viability of the entire PCS industry, the consumer benefits of cellular competition, and the net proceeds of the PCS auction are all contingent upon expeditious licensing.

---

[19] See, e.g., projections provided to the FCC PCS Task Force by Barry Goodstadt, EDS Management Consulting Services, March 23, 1994.

VI. CONCLUSIONS

Time Warner foresees PCS as a fully integrated communications platform that will spawn a wide range of new wireless mobile and fixed telecommunications offerings, affordable to average Americans, while bringing needed competition to cellular and wireline operators. While PCS operators initially will focus on voice applications, Time Warner anticipates that, within a relatively short time period, the "digital-friendly" nature of the new PCS networks will lead to the introduction of an array of un-tethered data and imaging applications which consumers and businesses will soon find indispensable.

To deliver on this promise, however, PCS operators must be provided a regulatory framework which facilitates prompt initiation of service, promotes the development of economically efficient system infrastructure and encourages strong new entry. Key to such a regime is the creation of wide bandwidth, large area PCS assignments and the exclusion of in-market PCS licensing of cellular carriers. Of nearly equal importance is the need for PCS licenses to be issued expeditiously.

Wide bandwidth assignments (i.e., 40 MHz or greater) can lead to lower subscriber costs by increasing system traffic handling capabilities and reducing network infrastructure requirements. Wider bandwidths are also necessary to compensate for the inherent technical differences between the two services'

frequencies and put PCS quality and coverage on par with cellular. In addition, 40 MHz or wider assignments facilitate transitional frequency sharing with incumbent microwave users thereby permitting earlier service introduction.

Likewise, large geographic license areas minimize infrastructure and operating costs by allowing for an efficient network layout. As demonstrated by the evolution of cellular systems (and more recently SMR systems), wireless markets generally are much larger than the MSA/RSA structure in which licenses were issued originally. Thus, a scheme which licensed geographically small areas would impose an unnecessary cost of consolidation on operators that would be passed on to consumers.

To ensure that consumers enjoy the low prices and innovation associated with competition, parties with significant cellular interests should not be permitted to hold PCS licenses in the same area. Among other things, PCS is envisioned to provide much needed competition to the cellular duopoly structure. Moreover, cellular operators are already beginning to provide some of the new services PCS licensees are expected to offer. The FCC should not squander the opportunity to inject real competition into this marketplace.

Finally, based on economic projections Time Warner has conducted, time-to-market is a key indicia of success for PCS licensees. Because a PCS operator must realize a significant level of penetration to achieve profitability, and inasmuch as cellular penetration is growing at a phenomenal rate, operators

who initiate service too late may find no market left to penetrate. Thus, even with wide bandwidth, large area assignments, if PCS operators are unable to enter the market soon, they may find it virtually impossible to build a successful business.